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**RURAL EQUITABLE ECONOMIC GROWTH ACTIVITY**

**Contract No. 519-C-00-94-00154-00**

# PRICE ELASTICITIES OF IMPORTS FOR BASIC GRAINS IN EL SALVADOR

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# EXECUTIVE SUMMARY

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El Salvador is the most important net importer of basic grains in Central America. Given the ongoing trade liberalization and bilateralization agreements in these markets, knowledge of the price elasticity of imports is crucial in guiding policy and trade agreement decisions.

The major purpose of the study was to provide estimates of the price elasticities of imports for three basic grains in El Salvador: maize, red beans, and rice. A subsidiary objective was to train personnel of the Ministry of Agriculture and Livestock on the underlying econometric procedures and results.

This report provides three alternative estimates for import elasticities and compares them to provide a consensus estimate for each of the three basic grains considered. Using 1975-97 data for the econometric analysis, the price elasticities of import demand were computed for the last 12 years (1986-97). The main findings are:

(1) Using constant elasticities of domestic demand and supply, the derived import elasticities averaged: -3.46 for maize, -11.81 for red beans, and -0.43 para for rice in the 1986-97 period.

(2) Using time varying elasticities derived from an LA/AIDS model for demand and a normalized, quadratic profit function for supply, the derived import elasticities averaged: -7.65 for maize, 2.28 for red beans, and -2.71 for rice.

(3) Using computed elasticities estimated directly from an import demand equation model the import elasticities averaged: -6.89 for maize, -7.37 for red beans, and -3.38 for rice.

(4) Comparing of the rankings and mean differences of the estimated elasticities across the three sets of estimates, statistical testing showed that neither their rankings nor their means are statistically different. The only exception was that the mean of the directly estimated import elasticity for maize was statistically different from the ones estimated by the other two methods.

# SECTION I

# INTRODUCTION

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# INTRODUCTION

## Introduction

El Salvador is the most important net importer of basic grains in Central America. Given the ongoing progressive liberalization of its grain markets, one of the most important issues is the responsiveness of import flows to price changes, that is, the price elasticity of imports.

The purpose of this report is to provide a set of estimates of price elasticities of imports for three basic grains: maize, red beans, and rice. The elasticity for sorghum imports is not considered because this subsector has shown lack of import activity en the last two decades; therefore, the lack of data does not support empirical estimation. Three alternative sets of estimates are presented and compared along with the implications for trade liberalization.

The first two methods are based on trade weighted price elasticities of domestic supply and demand, while the third presents elasticities based on import demand functions specified directly. A corollary objective was to strengthen the Ministry of Agriculture and Livestock's capacity to quantitatively analyze past, present and future commercial policy with respect to basic grains. This objective was accomplished through work with the consultant and through teaching and training modules that are reported separately.

## A. General Approach

In order to discuss the different elasticity estimates, it is useful to think of them in the following context. For a given basic grain, El Salvador's net imports can be represented by:

$$M_i = D_i\,(P_i^d\,,\,Y_i) - S_i\,(P_i^s\,,\,Z_i\,), \qquad (1)$$

Where $I$ is a commodity index ($I$ = maize, beans, or rice), $P_i^s$ is a vector of consumer prices, $Y_i$ is income, $P_i^s$ is a vector of supply prices, and $Z_i$ is a vector of factor costs and weather. $D_i\,(\bullet)$ denotes domestic consumer demand and can be derived theoretically from constrained utility maximization. $S_i\,(\bullet)$ denotes supply by domestic producers and can be derived theoretically from either technology or a profit function.

## B. Data

Data used in this report was supplied by the technical staff of the Ministry of Agriculture and Livestock of El Salvador, especially by the Dirección General de Economía Agropecuaria (DGEA) and the Office of Agricultural Policy Analysis (OAPA). Sources included *International Financial Statistics* of the Monetary Fund (Gross Domestic Product and the consumer price index), *Política Agrícola*, volumes II (by Pleitéz) and III (by Ramos, Worman, and Hugo) of the Ministerio de Agricultura y Ganadería for production, yields, imports and exports, and for the agricultural wage rate DGEA's reports on cost of production. Production and trade data for the 1990s were obtained from computer files supplied by DGEA and OAPA. Annual observations were collected for the 1975-97 time period.

The effect of weather on yields was measured with a Stallings' index. First, expected yields for maize, beans, rice, and sorghum were obtained by regressing yield on time and using the predicted values as expected yield. Then a weather variable was measured as the ratio of actual to expected yield. The four resulting weather variables were correlated and the alternative crop whose weather was the most highly correlated with a given basic grain was chosen in lieu of a grain's own weather variable. The weather index for sorghum was used for red beans. The rice and maize index were interchanged to avoid spurious correlation.

# SECTION II

# IMPORT OF BASIC GRAINS

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# IMPORT OF BASIC GRAINS

## A. Derived Import Elasticities

When grain imports are perfect substitutes for grains produced and consumed domestically, import elasticities can be calculated from domestic demand and supply elasticities (Johnson, 1977; Goldstein and Khan, 1985). Letting $P_i$ denote the price for the commodity in question, and manipulating *(1)*, a country's price elasticity of demand for imports can be expressed as:

$$N_{im} = -( W_{di}N_i + W_{si}\, \theta_I), \qquad (2)$$

Where $N_{\mathrm{im}}$ is the price elasticity demand for grain $I$; $n_i$ is the price elasticity of domestic demand(in absolute value), and $\theta_I$ is the price elasticity of domestic supply. The terms $W_{di}$ $( = D_{i\,I} / M_i )$ y $W_{si} / M_I$ are weights attached to those elasticities.

The first set of estimates came from using the estimates of $N_i$ and $\theta_I$ from a domestic supply and demand analysis contained in a previous report (López, 1998). In this report, the long run price elasticities of supply were estimated at 0.261 for maize, 0.571 for red beans, and 0.222 for rice. The price elasticities of domestic demand were estimated at –0.553 for maize, -0.601 for red beans, and –0.530 for rice.

The first set of estimates are derived from domestic demand and supply elasticities which are constant over time. These elasticities were then weighted by the computed $W_{di}$ and $W_{si}$ for each year. The results are shown in Table 1. The price elasticities for maize inputs averaged –3.46 in the 1986-97 period. Those for beans and rice averaged –11.81 and –4.03 respectively.

The second set of estimates came from price elasticities of demand and supply which were allowed to change over time. The demand functions were first estimated with Almost Ideal Demand System (AIDS) model and the elasticities computed accordingly for each year. The supply functions were derived from a dual profit for the grain's market. Assuming a normalized, quadratic profit function, the resulting supply function are linear in parameters. The appendix summarized the theory and empirical procedure used to calculate the parameters from the demand and supply functions and the implied price elasticities.

Using the calculated time varying domestic price elasticities and the weights $\mathrm{W}_{\mathrm{di}}$ and $W_{si}$.the import demand elasticities shown in Table 1 were obtained. The import price elasticities for maize, beans, and rice were estimated at -7.65, -2.28, and -2.71, respectively.

## B. Direct Estimation of Import Elasticities

The residual demand for imports in *(1)* can be expressed as:

$$M_i = f\,(\,P_i \;\; P_i^{\,d},\, Y_i,\, P_i^{\,s},\, Zi) \qquad (3)$$

The exchange rate is not included since the grain prices are expressed in domestic currency. (In practice, it is in any case rather difficult to separate the effect of exchange rat from other effects).

The third set of results came from implementing a linear function to obtain time varying elasticities of grain imports with respect to each grain's own price. Then yearly elasticities were obtained by $N_{mi} = \$_l\,(P_i / M_i)$, where $\$_l = dM_i / dP_i$. These estimated elasticities are also shown in Table 1. The average import price elasticities for maize, beans, and rice were estimated at -6.89, -7.37, and -3.38, respectively.

**Table 1: Alternative Estimates of Price Elasticities of Imports for Basic Grains**

| | **Derived from Constant** | | | **Derived from Varying** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **0 y ,** | | | | | **0 y ,** | **Direct Estimates** | | |
| **Year** | **Maize** | **Beans** | **Rice** | **Maize** | **Beans** | **Rice** | **Maize** | **Beans** | **Rice** |
| 86 | -3.797 | -14.866 | -5.483 | -5.638 | -3.155 | -2.728 | -5.149 | -8.914 | -3.378 |
| 87 | -8.149 | -7.947 | -3.564 | -15.39 | 0.331 | -2.03 | -13.665 | -3.152 | -2.206 |
| 88 | -4.169 | -32.536 | -12.82 | -8.186 | -7.999 | -6.486 | -8.1 | -13.869 | -8.274 |
| 89 | -2.559 | -11.054 | -5.238 | -5.548 | 1.587 | -3.708 | -4.981 | -6.1 | -5.158 |
| 90 | -7.694 | -8.78 | -1.718 | -16.844 | -2.762 | -1.358 | -14.875 | -5.711 | -1.847 |
| 91 | -1.139 | -5.084 | -3.122 | -2.875 | -2.231 | -2.413 | -2.424 | -4.265 | -2.519 |
| 92 | -2.999 | -5.009 | -4.724 | -9.008 | 0.533 | -4.185 | -7.805 | -6.743 | -4.552 |
| 93 | -2.278 | -6.084 | -2.402 | -6.826 | -2.769 | -2.288 | -6.634 | -4.399 | -2.982 |
| 94 | -2.702 | -4.274 | -1.864 | -5.343 | -2.044 | -1.847 | -4.782 | -3.963 | -2.321 |
| 95 | -1.022 | -2.017 | -1.858 | -3.865 | -0.317 | -1.644 | -3.299 | -2.693 | -2.076 |
| 96 | -1.602 | -32.209 | -1.589 | -4.664 | -3.121 | -1.101 | -4.077 | -21.282 | -1.866 |
| 97 | -3.324 | -13.873 | -1.967 | -10.497 | -4.388 | -2.317 | -8.764 | -10.868 | -2.834 |
| Mean | -3.46 | -11.81 | -4.03 | -7.65 | -2.28 | -2.71 | -6.89 | -7.37 | -3.38 |
| St Dev | .2.41 | 10.75 | 3.25 | 4.55 | 2.32 | 1.56 | 4.05 | 5.59 | 1.96 |

## C. Comparison of Results

To assess differences among the elasticities in Table 1, t-tests were conducted to ascertain whether the means of the import elasticities for a given grain under the three methods were significantly different from each other. Of the three resultant tests, Table 2 shows that only the means of 2 and 3 for maize were statistically significant at the 5% level (critical t-statistic = 1.796 for 11 d.f.). All other mean differences were not statistically significant at this level.

Again there is a possible critical difference in the means of maize import elasticities using methods 1 and 2. Their mean difference is statistically significant at 15% level. However, there is not a statistically significant difference between the maize elasticities estimates for methods 2 and 3. This can lead one to conclude that for maize, and average of the elasticities under methods 2 and 3 is probably a more reliable estimated than that provided by method 1.

Thus, based on the results in table 2 and taking the average elasticity across the three methods (excluding method 1 for maize), the best estimates of the price elasticities of imports for basic grain in El Salvador are: -7.27 for maize, -7.15 for red beans, and -3.23 for rice. Finalmente, Spearman-Shearson rank correlation coefficients do show a congruous ranking of the estimated import elasticities over 1986-97 period. Thus, in general both the mean ranking of the estimated import elasticities were consistent across the three methodologies employed.

**Table 2. Means Test Statistics for Alternative Estimates of Price Elasticities of Import for Basic Grains in El Salvador.**

| | Estimate | |
|---|---|---|
| Estimate Type | Method 1 | Method 2 |
| | Mean Differences (t-statistics) | |
| *Maize* | | |
| Method 2 | 0.844 | -- |
| | (1.313) | |
| Method 3 | -3.594 | -4.438 |
| | (-0.591) | (-2.43) |
| *Red Beans:* | | |
| Method 2 | -5.200 | |
| | (-1.151) | |
| Method 3 | 4.315 | 9.512 |
| | (0.761) | (1.09) |
| *Rice:* | | |
| Method 2 | -0.693 | |
| | (-0.280) | |
| Method 3 | 0.494 | 1.187 |
| | (0.332) | (0.648) |

Note: Method 1 = Derived import elasticities with constant domestic demand and supply elasticities. Method 2 = Derived import elasticities with time varying domestic demand and supply elasticities. Method 3 = Direct estimates of import elasticities. Only the 1986-97 elasticities are included.

# SECTION III

# APPENDIX: TIME VARYING ELASTICITIES OF DOMESTIC SUPPLY AND DEMAND

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## A. Derivation of the Price Elasticities of Supply

The application of duality theory has become a popular way of approaching production economics analysis. Since there is one to one correspondence between the technology and its dual transformation, the normalized profit function is the preferred way to drive theoretically consistent supply equations when the possibility of joint technology exists (Lau, 1972; Shumway, 1983).

A quadratic normalized profit function can be represented by:

$$II^* = a_o + \underset{I}{E}\ a_i p_i^* + \tfrac{1}{2} \underset{I\,j}{EE}\ a_{ij}\, p_i^*\, p_j^* + \underset{I\,k}{EE}\ b_{ik}\, p_i^*\, z_k, \qquad \text{(Ai)}$$

where j,k = maize, beans, or rice; *a* and *b* are vectors of fixed parameters, $p_{i\,i}$s the price of output or import *I*, and $z_k$ is a vector of non-price factors.

Applying Hotelling's Lemma, a system of netputs (supply import demand equations) is obtained:

$$\frac{MII^*}{Mp_i} = Q_i^{s*}(p, Z). \qquad \text{(A2)}$$

In this case $Q_i^s$, es el abastecimiento, porque el precio de la única importación considerada (fertilizante) fue utilizado como un numerario para normalizar las utilidades y los precios. Z is a vector of shifted factors (in this case weather). To generate reasonable output supply equations, the profit function must be twice differentiable, in this case with respect to the output prices (Dietwert 1973). The equation is thus represented by:

$$Q_i^s = a_i + a_{ij}\, p_j + b_{ik}\, Z_k + u_{is} \qquad \text{(A3)}$$

Where $Q_i^s$, Z are quantity supplied, and other factors; $u_{is}$ is the error term and the resto of the notation is as defined above. A system of three estimating equations were estimated by Zellner's seemingly unrelated equations technique. Yearly supply elasticities were derived by applying the formula: $,_i = a_{ij} * (p_j / Q_i^s)$. The results are presented in Table 3.

## B. Derivation of the Price Elasticities of Demand

On the demand side, use is made of the Almost Ideal Demand System (AIDS), whose starting point is a class of preferences, namely, the price-independent generalized logarithm (PIGLOG). The PIGLOG function represent a minimum expenditure at a given utility level and permits exact aggregation over consumers (Rajan, 1980).

The estimating equations are derived from a first order approximation to the general demand relation among budget share, log of expenditure, and log of prices. By assuming weak separability, a two-stage budgeting process is applied. In the first stage, a consumer allocates his total expenditure among broad categories, say rent, health and, basic grains and other foods. In the second stage, the consumer allocates the sub-budget to individual commodities. Weak separability presumes independence of preferences. By this assumption, the commodities at the second stage of the budgeting process are treated as a different category from all other groups.

The estimation process applies the Linear Approximate Almost Ideal Demand System (LA/AIDS), a variant of AIDS that uses the Stone price index to obtain the general index for deflating the expenditures. The LA/AIDS is flexible enough without unduly restricting consumer preferences, allows for the imposition of demand theory constraints such as symmetry and homogeneity to make the estimation process theoretically consistent, and makes linear estimation possible (Deaton and Muelbauer, 1980). A system of estimating demand equations is present by:

$$W_i = b_i + E\, b_{ij} \log p_j + c_i \log (X / PI) + u_{iw} \qquad \text{(A4)}$$

The theoretical restrictions are:

Homogeneity: $E_I \; b_{ij} = O$,
Symmetry: $b_{ij} = b_{ij} \quad y$,
Adding up: $E_I \; b_{ij} = 1$, $E_j \, b_{ij} = O$, $\quad E_I \; c_j = O$.

The term $W_i$ is the budget share, X is total expenditure in the commodity group, while PI is the Stone index, which is given by

$$\text{Log PI} = E_i \, W_i \log p_i \qquad \text{(A5)}$$

La variable $p_i$ represents the individual farm level prices for each grain. The dependent variable in the demand estimating equations is the budget share for a grain, with each explanatory variable being the price of a grain, the price of the substitute and total basic grain expenditure deflated by Stone's price index. The budget share is obtained by dividing $(p_i^d \, q_i^d)$ by $(E p_i^d \, q_i^d)$.

It should be noted that the budget shares sum up to one; therefore the covariance matrix of equation errors therefore is singular. This necessitates dropping one equation (e.g. rice) for estimation. The parameters of the omitted share equation can be obtained by using the adding up restrictions. The demand system will also be estimated separately, with the homogeneity and symmetry restrictions imposed. Then, demand Elasticities are obtained using the following formula:

Own demand elasticity: $-1 + a_{ij} \,/\, w_i - c_i I = j$

Note, that the use of LA/AIDS required that the demand elasticities be derived using different formulas than the ones applied in the AIDS model (Green and Alston, 1990). The estimated demand elasticities are reported in Table 4.

**Table 3 - Yearly Elasticities of Supply, Profit Function Model.**

| Year | Maize | Beans | Rice |
|---|---|---|---|
| 75 | 0.234 | 0.275 | 0.191 |
| 76 | 0.279 | 0.298 | 0.303 |
| 77 | 0.258 | 0.396 | 0.451 |
| 78 | 0.201 | 0.29 | 0.292 |
| 79 | 0.159 | 0.247 | 0.213 |
| 80 | 0.113 | 0.161 | 0.145 |
| 81 | 0.085 | 0.191 | 0.132 |
| 82 | 0.129 | 0.243 | 0.196 |
| 83 | 0.118 | 0.279 | 0.167 |
| 84 | 0.148 | 0.302 | 0.143 |
| 85 | 0.177 | 0.485 | 0.106 |
| 86 | 0.132 | 0.181 | 0.099 |
| 87 | 0.134 | 0.525 | 0.149 |
| 88 | 0.126 | 0.2 | 0.123 |
| 89 | 0.13 | 0.216 | 0.156 |
| 90 | 0.183 | 0.296 | 0.138 |
| 91 | 0.241 | 0.237 | 0.153 |
| 92 | 0.158 | 0.204 | 0.187 |
| 93 | 0.147 | 0.222 | 0.118 |
| 94 | 0.179 | 0.227 | 0.118 |
| 95 | 0.164 | 0.227 | 0.146 |
| 96 | 0.132 | 0.291 | 0.141 |
| 97 | 0.237 | 0.216 | 0.12 |
| | | | |
| Mean | 0.17 | 0.27 | 0.18 |
| St Dev | 0.05 | 0.10 | 0.08 |

**Table 4- Yearly Elasticities of Demand LA/AIDS Model.**

| **Year** | **Maize** | **Bean** | **Rice** |
|---|---|---|---|
| 75 | -0.729 | -0.0697 | -0.69 |
| 76 | -0.696 | -0.344 | -0.639 |
| 77 | -0.745 | -0.0093 | -0.565 |
| 78 | -0.735 | -0.0011 | -0.697 |
| 79 | -0.714 | -0.186 | -0.716 |
| 80 | -0.649 | -0.458 | -0.702 |
| 81 | 0.696 | -0.351 | -0.617 |
| 82 | -0.703 | -0.338 | -0.561 |
| 83 | -0.748 | 0.088 | -0.607 |
| 84 | -0.757 | 0.299 | -0.625 |
| 85 | -0.752 | 0.067 | -0.489 |
| 86 | -0.727 | -0.218 | -0.51 |
| 87 | -0.763 | 0.465 | -0.6 |
| 88 | -0.67 | 0.443 | -0.558 |
| 89 | -0.742 | -0.091 | -0.452 |
| 90 | -0.722 | -0.257 | -0.484 |
| 91 | -0.695 | -0.344 | -.0642 |
| 92 | -0.757 | 0.255 | -0.591 |
| 93 | -0.668 | -0.464 | -0.529 |
| 94 | -0.703 | -0.344 | -0.543 |
| 95 | -0.749 | 0.036 | 0=-0.506 |
| 96 | -0.759 | 0.114 | -0.341 |
| 97 | -0.721 | -0.24 | -0.565 |
| | | | |
| Mean | -0.719 | -0.137 | -0.591 |
| St Dev | 0.033 | 0.270 | 0.077 |

# ANNEX A

# REFERENCES

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